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PROCUREMENT SECTION

WHAT IS AN ACCEPTABLE ALLOWABLE ERROR AND SAMPLE SIZE IN SAMPLE LOG SCALING OR TREE MEASURING

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When a sampling technique of any kind is substituted for complete measurement, one accepts the fact that a certain sampling error exists.[1/] If the sample has been chosen in strictly random fashion one knows, for a given probability, exactly what the limits of the sampling error will be. In other words the error will lie somewhere within these plus or minus limits. As the sample size is increased, approaching 100 percent tally as a limit, the sampling error approaches zero. The error does not approach zero, however, in direct proportion to the increase in sample size. For example, a small increase in sample size is required to reduce a sampling error from 5 percent to 4 percent, whereas a very large increase is required to reduce it from 2 percent to 1 percent. It follows, then, that a point of diminishing returns will be reached where a further increase in the sample size is not justified by the concomitant decrease in sampling error (or increase in sampling accuracy).

In scaling sawlogs, for example, the use of sampling methods means a willingness on the part of the seller to risk a possible monetary loss rather than to spend additional funds for a more accurate scale. Several factors will determine how large the risk should be or whether it should be taken at all.

1/ Sampling error in sample log scaling or tree measuring is the difference between the volume estimated by the sampling method and the volume obtained by complete measurement expressed as a percentage of the latter. It is assumed that the complete measurement is without error, which, of course, is not strictly true. In log scaling, for example, a scale of sound material is considered satisfactory if it is within 2 percent of a check scaler's volume for the same logs, whereas a scale of defective material is often accepted at a higher discrepancy than 2 percent.

The most obvious factor which influences allowable error is the total value of the sale. It is reasonable that a lower percentage error should be the goal on a high-priced sale than would be allowed on a low-priced sale. This fact is true whether the sale is high-priced because of its size or its quality.

Natural variation among the sampling units (logs, trees, or truckloads), commonly expressed as the coefficient of variation, is a second factor which influences the acceptable sampling error. Uniform material, that is material whose volumes have a low coefficient of variation, requires less intensive sampling to achieve a given accuracy than highly variable material. For this reason, greater sampling accuracy can be justified for uniform material before reaching the point of diminishing returns.

The cost of measuring a sampling unit (log, tree, or truckload) is a third factor which has an important influence on the magnitude of the acceptable sampling error. If scaling is costly, the point of diminishing returns will be reached sooner (resulting in a larger allowable error) than if scaling is cheap. It is assumed, of course, that the cost per unit does not change with different sampling rates.

Finally, the number of sampling units in the sale influences the size of sample required to meet a given accuracy. Sample size must be increased (although not directly) as the total number of units increases. Usually, however, for a given total sale value, the sale with the larger number of units will have the lower coefficient of variation. Furthermore, the larger number of units for a given total value will usually indicate smaller units with correspondingly lower scaling costs per unit. Because of these two compensating factors, number of units can be omitted in the calculation of allowable error. Having decided on an acceptable error, however, the total number of sampling units in a sale must be used as one of the variables in deciding actual sample size and sampling rate.

Blythe[2/] first calculated the point of diminishing returns in computing sample size in log scaling. Figure 1 employs Blythe's formula in an alinement chart and is extended to include the calculation of allowable error. Three variables, (a) measuring cost per unit (in dollars), (b) the coefficient of variation of volumes among the sampling units, and (c) total sale value are included in the alinement chart. Instructions for using the chart are printed with the figure.

Having decided upon a suitable allowable sampling error and knowing the coefficient of variation of the material and the total number of units in the sale, the required sample size can be found from the appropriate graph in figure 2.

2/ Blythe, R. H. Jr. The economics of sample size applied to the scaling of sawlogs. Biometrics Bull. 1: 67-70. 1945.

APPLICATION

In the application of the chart in figure 1, total sale value can be closely estimated from the sale contract or appraisal. Scaling costs per unit must be determined from experience for specific conditions. Often scaling costs are high because of lost time in waiting for loads at a landing or because of travel time, and a system of sample scaling may or may not afford a saving. Coefficients of variation are difficult to estimate without a previous sample of the material. Methods for computing the coefficient of variation have been presented in detail by Lynch.[3/]

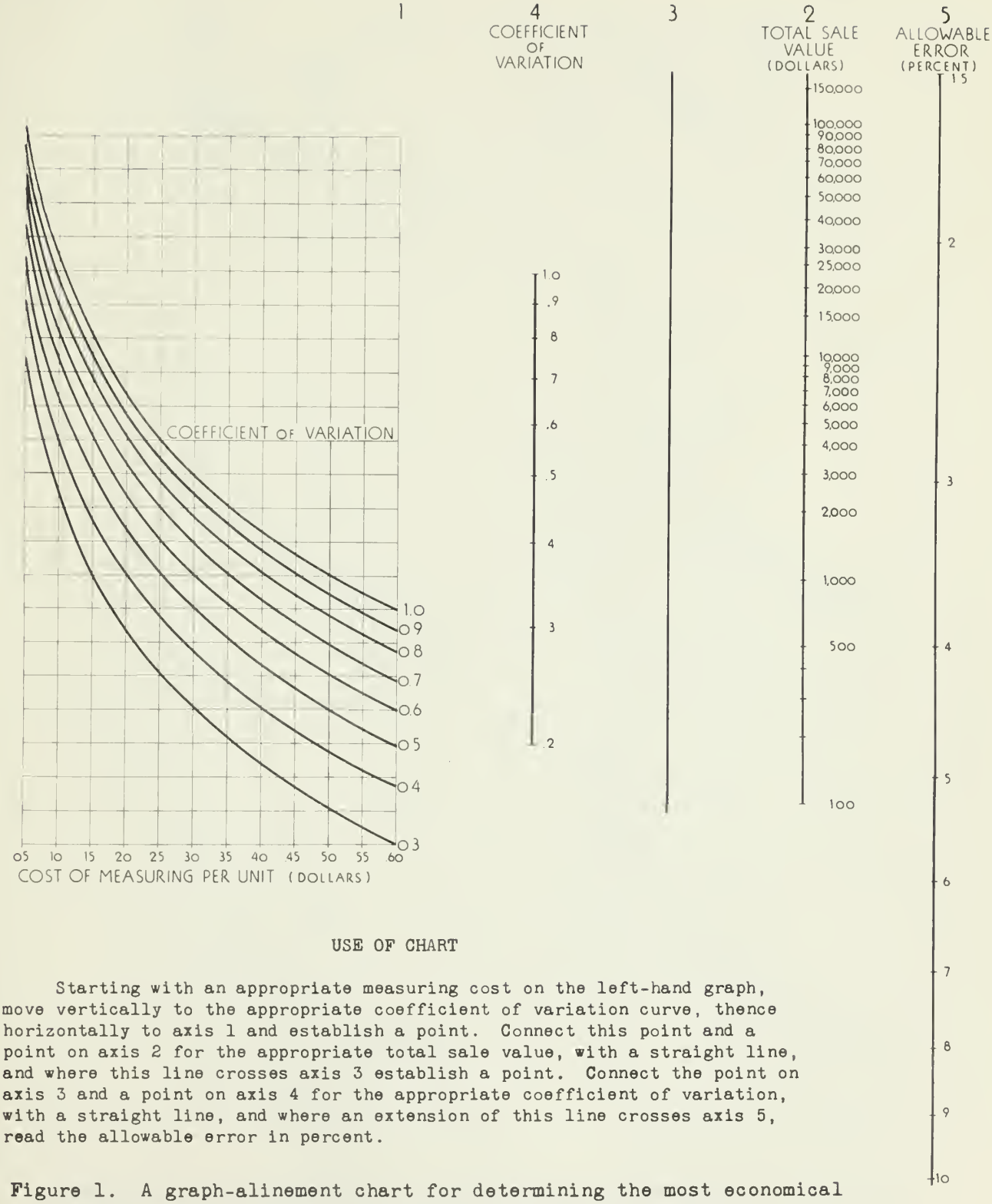
As an example of the use of figures 1 and 2, assume a timber sale of 2,000 M b. m. of mixed timber with an average total stumpage value of $10 per M (including all assessments), or a total sale value of $20,000. Because of the overmature nature of the stand, the logs are expected to be rather variable in volume with a coefficient of variation of 0.8. Previous experience has shown that scaling under the particular conditions of this sale costs about 15¢ per log.

On the left-hand graph of figure 1, begin with a 15¢ scaling cost, follow vertically to the 0.8 coefficient of variation curve and thence horizontally to a point on axis 1. With a straight edge, connect this point with the value $20,000 on axis 2, and where the line crosses axis 3, establish a point. Next, connect the point on axis 3 and a point on axis 4 opposite the coefficient of variation 0.8 with a straight-edge, and where an extension of this line crosses axis 5 read a value slightly higher than 2 percent.[4/]

To obtain sample size, turn to figure 2 and the graph for an 0.8 coefficient of variation. Assuming that the number of logs in this sale is estimated to be 12,000, then for an allowable sampling error of 2 percent, approximately 1,400 logs will be required in the sample scale. The ratio of 1,400 to 12,000 is about 1 out of every 9 logs.

3/ Lynch, Donald W. Sampling in tree measurement sales on Northern Region National Forests. Northern Rocky Mountain Forest and Range Experiment Station. Station Paper No. 27. April 1951.

4/ If a combination of conditions indicates an allowable error of less than 1.5 percent, it is doubtful if sampling is justified unless the number of units in the sale is very large. Sample sizes increase at a rapid rate as allowable errors are reduced below 2 percent.



USE OF CHART

Starting with an appropriate measuring cost on the left-hand graph, move vertically to the appropriate coefficient of variation curve, thence horizontally to axis 1 and establish a point. Connect this point and a point on axis 2 for the appropriate total sale value, with a straight line, and where this line crosses axis 3 establish a point. Connect the point on axis 3 and a point on axis 4 for the appropriate coefficient of variation, with a straight line, and where an extension of this line crosses axis 5, read the allowable error in percent.

Figure 1. A graph-alinement chart for determining the most economical allowable error in sample scaling and sample tree measuring.

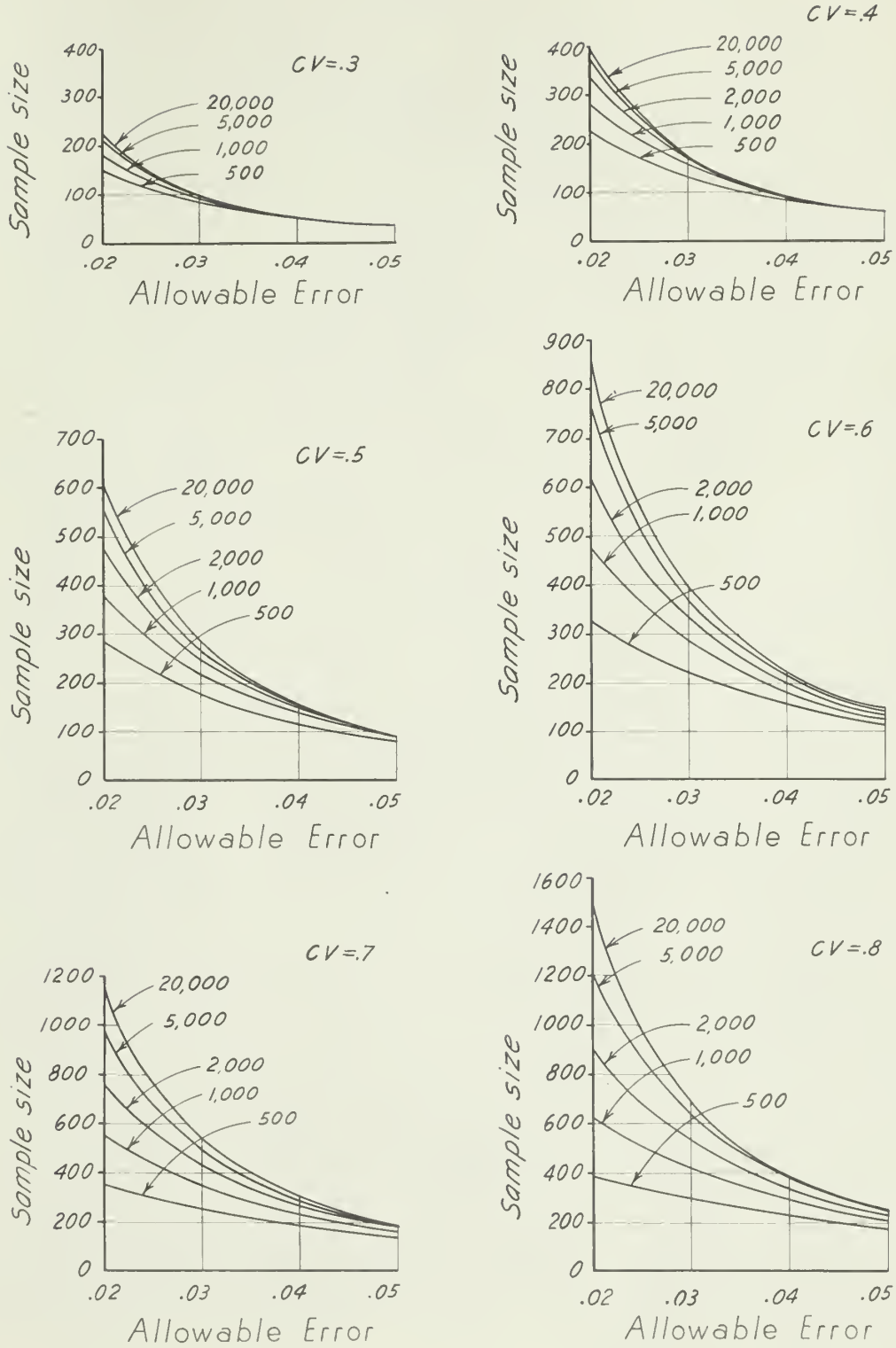


Figure 2. Graphs showing the number of units in the sample needed for allowable errors of 2 percent to 5 percent, for sale sizes of 500 to 20,000 units, and coefficients of variation of 0.3 to 0.8.